Biology of Three *Callirhytis* Gall Wasps from Pacific Slope *Erythrobalanus* Oaks

(Hymenoptera: Cynipidae)

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This paper presents life histories of two species of alternating unisexual and bisexual generation gallmaking cynipids, *Callirhytis eldoradensis* (Beutenmuller) (= *Andricus eldoradensis* Beutenmuller, 1913) and *Callirhytis flora* Weld ♂♀ (1922a) (= *Callirhytis milleri* Weld ☿, 1922b) new synonym, and a description of the males of a third species, *Callirhytis perfoveata* (Kinsey) ♂♀ (1922).

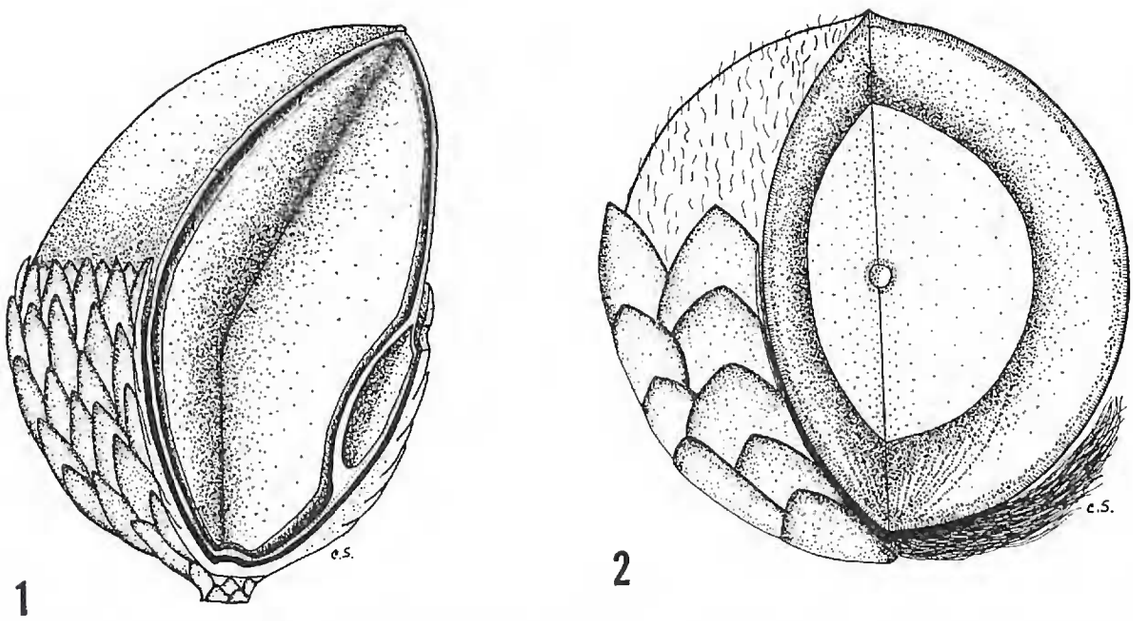
All three of these gallmaking cynipid species occur on all three species of Pacific slope oaks in the subgenus *Erythrobalanus*: *Quercus agrifolia* Nee, *Quercus kelloggii* Newberry, and *Quercus wislizenii* A. DeCandolle.

CALLIRHYTIS ELDORADENSIS (Beutenmuller), new combination

Callirhytis eldoradensis emerges from integral acorn hull galls in aborted acorns (Fig. 1). The original description included only males and erroneously associated them with galls of *Callirhytis milleri* Weld. The bisexual generation female and correct gall were described by Weld (1922). This generation is unusual because the male is larger than the female and emergence is during late September and October rather than in the spring or early summer. The previously undescribed unisexual generation emerges in late spring or early summer from a spherical bud gall (Fig. 2).

Biology.—During October 1970 a collection of *C. eldoradensis* was reared indoors and individuals of both sexes were confined together in bags on three native *Q. wislizenii.* On the following two days seven naturally emerged (not escaped) males were collected on the bags' exteriors. This suggests the possibility of a female emitted pheromone. When the natural female emergence was beginning and bagged females began oviposition, three consecutive days of rain and cold weather interfered with observations and caused a high mortality of reared and possibly naturally emerged insects.

When the bags were removed in late March, 1971 the twigs contained green spherical bud galls about four mm in diameter with white basal hairs. The galls abort the apical meristem and are surrounded basally by the bud scales. Four of these galls figured as numbers 191–194 by



FIGS. 1–2. *Callirhytis eldoradensis*. Fig. 1. Bisexual generation gall, 5×. Fig. 2. Unisexual generation gall, 15×.

Houard (1935) were erroneously identified as *Andricus attractans* Kinsey, now in *Callirhytis*. They do not secrete honeydew as do *C. attractans* galls. They contain a succulent layer of nutritive tissue around the larval cell which provides a food and moisture reserve for the larva after the gall falls to the ground in April. Emergence is during the late spring or early summer, apparently the next year. One specimen reared at the U.S. National Museum emerged 27 April 1923 from galls collected May 1922. Another, reared indoors by the author, emerged prior to 15 June 1971 from galls collected April 1970. None of the adjacent limbs or trees, including the original source of insects, harbored the galls, probably due to both previous intensive collecting and inclement weather. Nor did any other unisexual generation galls occur on the isolated twigs.

Morphology of the unisexual generation requires transfer of the species from its previous assignment in *Eumayria* Ashmead to *Callirhytis* Foerster group B, which includes almost exclusively species associated with acorns.

The following additional circumstantial evidence also substantiates this association of alternate generations. Bisexual generations usually emerge about two to three months later than the unisexual generation, which in this case suggests natural emergence and oviposition of the unisexual generation about May or June. By this time the trees are usually completing seasonal growth and though galls can be induced in some differentiated nearly mature plant tissue (Lyon, 1970), one of the few

plant tissues still growing sufficiently to be an optimum oviposition site for this unisexual generation female is the rapidly enlarging acorns.

Callirhytis flora ♂♀, *C. milleri* ☿, and *Callirhytis carmelensis* Weld ☿ are the only other gallmaking cynipids known to be associated with Pacific Slope *Erythrobalanus* acorn galls. The first two are alternate generations of the same species and thus neither could be an alternate generation of *C. eldoradensis*. It is highly unlikely that both generations of a cynipid would occur on a tissue so limited in availability as acorns, especially since a large brood of *C. carmelensis* would abort the acorns needed for a brood of *C. eldoradensis*. Also though acorns of both *Q. kelloggii* and *Q. wislizenii* require two seasons to mature and might receive eggs during the first ⅔ of their time on the tree and sustain the bisexual generation of *C. eldoradensis*, *Q. agrifolia* matures acorns in only one season. Thus the typical winter emerging unisexual generations, such as *C. carmelensis*, cannot be part of the life cycle of *C. eldoradensis* because on *Q. agrifolia* they would have no acorns available in which to oviposit. There are no other known spring or early summer emerging unisexual generations associated with acorns which might potentially be considered as the alternate generation of *C. eldoradensis*.

Systematics.—Female. Head: nearly massive, broadly triangular in front view, widest at antennal socket level, slightly narrower than thorax. Occiput darker, elevated about ½ width of ocellus above head contour. Cheeks widened behind eyes. Malar groove absent, malar area pubescent with fan-shaped striae radiating from clypeus corners. Antenna 13 segmented, last segment twice the length of the preceding. Thorax: mesoscutum sparsely pubescent, with fine transverse rugosity. Notaulices weakly complete, distinct only posteriorly. Anterior parallel lines and parapsidal lines extending nearly ½ length of mesoscutum. Median groove polished, ⅕ length of mesoscutum. Scutellum coriaceous centrally, reticulate laterally; foveae reticulate medially, polished smooth laterally. Mesopleuron ridged longitudinally. Tarsal claws simple. Wings: veins pale yellow-brown; faintly clouded, surface with short pubescence, margin bare. Radial cell open, aerolet ¼ length of open cubital cell. Abdomen; first tergite polished smooth with dorsally interrupted pubescent ring at base, succeeding tergites polished micropunctate, three tergites visible dorsally. Ventral spine 12 times as long as wide, sparsely pubescent, forming 90° angle with ventral valves, equal to length of entire hind tarsus. Color: amber, abdomen darker.

Type Deposition.—Plesiotype female in U.S. National Museum.

CALLIRHYTIS FLORA Weld

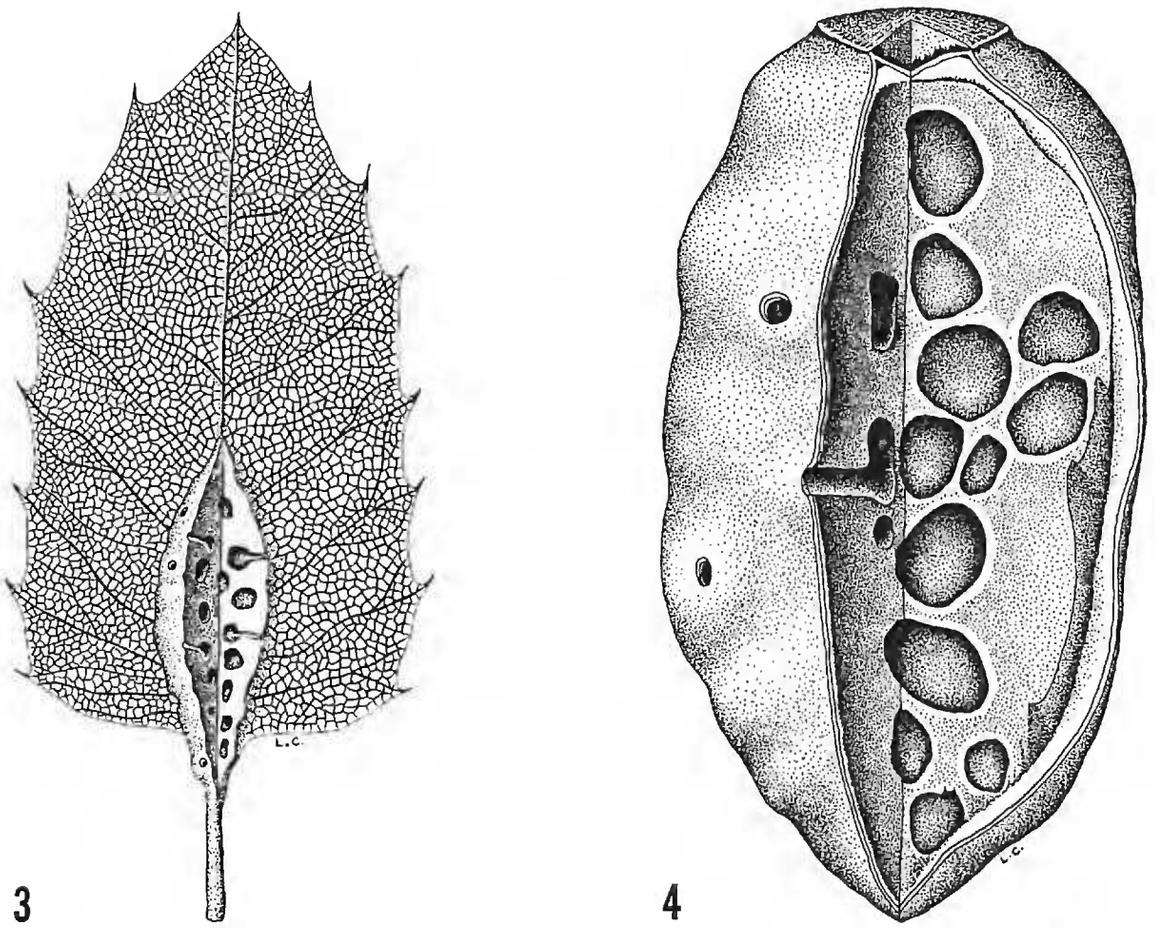
Callirhytis flora, which was described from females (though Weld also reared males) that emerged from an integral hard midrib leaf gall (Fig. 3) during May and June, is the alternate bisexual generation of *Callirhytis milleri*, new synonym which emerges between late Feb-

ruary and mid March from lumpy aborted acorn cotyledons (Fig. 4). Unisexual generation galls have been illustrated by Beutenmuller (1913) and Weld (1922b). The former erroneously associated them with *Callirhytis eldoradensis*. Bisexual generation galls are also figured by Weld (1922a, 1957). Both generations belong to Weld's group B, which includes primarily unisexual generations from hard acorn galls. *C. flora* and *C. milleri* are hereby synonymized, with *Callirhytis flora* Weld having priority.

Biology.—On 20 March 1969 numerous unisexual generation females placed on *Q. wislizenii* with rapidly elongating buds readily oviposited in the midrib of the lower surface of young leaves. Bisexual generations usually take two or three months to develop, and the only known bisexual group B *Callirhytis* emerging from a leaf gall on California *Erythrobalanus* oaks during May to June is *C. flora*.

The long ovipositor of *C. flora* (9.3× head width) caused Weld to believe it oviposited in acorns. Such an ovipositor would only be necessary for ovipositing deep in plant tissue, such as the center of a maturing acorn. The senior author collected ten bisexual generation females of *C. flora* while they were ovipositing in acorns of *Q. agrifolia* and in second year acorns of *Q. wislizenii* during May and June 1967 to 1969. These acorns drop to the ground in the fall and the unisexual generation larvae remain in the galls at least 1½ years before pupation. Weld (1922b) has recorded a larval period lasting 2½ years.

C. flora and *C. milleri* key out to the same couplet (Weld, 1922b). This structural similarity of alternate generations is paralleled by that of *Callirhytis pomiformis* (Bassett) (Lyon, 1959). The only other known Pacific Slope gallmaking cynipids reared from *Erythrobalanus* acorn galls are *C. eldoradensis* and *Callirhytis carmelensis* Weld. Neither of these could result from the oviposition of *C. flora* because of the following reasons. *C. eldoradensis* from acorns is also a bisexual generation, and the alternate unisexual generation emerges from a spherical bud gall. Acorn pip galls of *C. carmelensis* develop during March and April and drop to the ground about May. The acorns of *Q. kelloggii* and *Q. wislizenii*, which require two years to mature, could receive eggs nearly any time during the first or second years and produce galls of *C. carmelensis*. However, *Q. agrifolia* produce mature acorns between February and October of the same year. Since the bisexual generation of *C. flora* emerges in June, any *Q. agrifolia* acorns in which they might oviposit would drop to the ground that autumn and not remain on the tree until the following spring. *C. flora* bisexual generation individuals



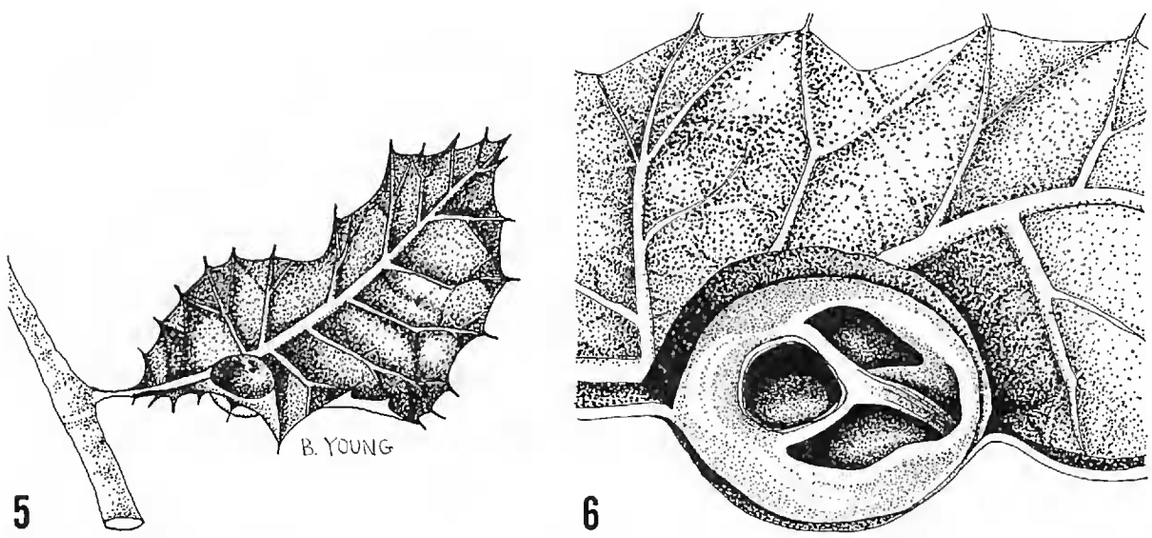
FIGS. 3–4. *Callirhytis flora.* Fig. 3. Bisexual generation gall, 2.5×. Fig. 4. Unisexual generation gall, 2.5×.

do not live through the winter until the following spring to be able to oviposit in the newly forming crop of acorns. *C. carmelensis* could therefore not be the alternate generation of *C. flora.*

Systematics.—Male. Head: massive, not widened behind eyes, malar space grooved; antennae 15 segmented, third excavated dorsally, last equal to preceding. Thorax: scutum coriaceous, coarse posteriorly, notaulices complete, anterior parallel lines distinct; foveae shallow, ridged, weakly separated; scutellum rugose, smoothest centrally; mesopleuron smooth dorsally and ventrally, coriaceous medially; wings pubescent, margins ciliate, veins pale beyond second crossvein. Abdomen: smooth, bare, brown, lightest dorsally, not pedicellate. Length: 1.7 mm. Color: frons, genae, antennae, and legs yellow-brown, remainder red-brown.

A unisexual generation male sport which emerged 22 January 1969 differs from bisexual generation males by its larger size (2.8 mm); uniformly brown wing veins; last antennal segment slightly longer than preceding; scutum finely rugose anteriorly, coarser posteriorly; polished coriaceous abdominal tergites.

Type Deposition.—Plesiotype bisexual generation male and unisexual generation male sport in U.S. National Museum. Plesioparatype males in the Weld collection in the possession of Robert J. Lyon, Los Angeles City College (3), California Academy of Sciences (10), senior author's collection (60), and U. S. National Museum (5).



FIGS. 5–6. *Callirhytis perfoveata*, bisexual generation galls. Fig. 5. Position of galls on leaf, 2×. Fig. 6. Detail of gall structure, 7×.

Distribution.—Probably found throughout the range of the host plants.

Parasite Biology.—Euderus crawfori Peck (Hymenoptera: Eulophidae) adults were dissected from larval cells of bisexual generation *C. flora* which contained partly consumed adult gallmakers indicating the parasites did not attack the gallmakers until the latter completed pupation.

CALLIRHYTIS PERFOVEATA (Kinsey)

When Kinsey described the rapidly developing spring cynipid *C. perfoveata* from six females (1922) he stated, "such species of cynipids are usually bisexual, so the male may yet be discovered for the species." This has been confirmed with the rearing of males from *Quercus wislizenii.*

Biology.—The green, nearly spherical, succulent, monothalamous integral leaf galls (Figs. 5 & 6) were noted by the senior author in the new growth of *Q. wislizenii* at Folsom Lake, Placer Co., California, 19 March, 1967. They were fully developed and contained mature larvae. On 23 March some contained white pupae. Galls collected then and maintained indoors 65–75° F yielded two females on 1 April. Galls still on the trees showed no evidence of natural emergence. From galls collected 15 April both males and females emerged from 20 to 29 April (indoors). By May over half of the galls examined on the trees had emergence holes. Sprenger collected *C. perfoveata* from *Q. wislizenii* in Rocklin, Placer Co., California on 13 and 14 April, 1973. Insects

emerged 13 to 27 April while being maintained indoors. Neither the oviposition site of the females nor the alternate unisexual generation is known. Galls have also been seen at Lemoncove, Tulare Co., and Clearlake, Lake Co., California.

Systematics.—Female. Similar to Kinsey's ♀ description, but with the following variation: proximal antennal segments yellow-brown darkening to deep brown distally; cheeks and malar space reddish-brown to black; mandibles yellow-brown to reddish-brown; median groove sometimes indistinct. Using maximum width of the head as a base, the mesonotum length ratio is 1.3, antennae 2.3, wings 3.7. Length of 48 specimens, 2.1–2.6 mm. Average 2.4 mm.

Male. Head coriaceous; from above transverse, as broad as thorax, not broadened behind eyes; in anterior aspect, interocular space twice as wide as high, malar space 0.2 eye height without groove; antennae 15 segmented. Mesonotum coriaceous, notaulices complete, broader behind, median groove less distinct than in females; scutellum rugose, smoother medially, fovea smooth and polished, separated by ridge; mesopleuron nearly bare, more striate ventrally. Wing hyaline, margin ciliated, veins brown, radial cell open, aerolet ⅙ wing length. Claws simple. Abdomen non-pedicellate, shorter than head plus thorax, tergite II smooth. Using maximum head width as base, mesonotum length is 1.4, antennae 3.3, wing 4.1. Length of 27 specimens, 1.8–2.4 mm, average 2.1 mm. Body, head, and antennae black, abdomen dark brown, lightest dorsolaterally on tergite two.

Type Deposition.—The series contains 27 males and 48 females. Plesioallotype male in U.S. National Museum. Plesiotype insects of both sexes and freeze dried galls have been deposited at the U.S. National Museum, California Academy of Sciences, Weld collection in the possession of Robert J. Lyon of Los Angeles City College, University of California at Davis, and in the authors' collections.

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SCIENTIFIC NOTE

Recovery of *Anax junius* from a glacier in the Sierra Nevada (Odonata: Aeschnidae).—On August 16, 1972, while traversing the Lyell Glacier in Yosemite National Park with Charles Dickson, ranger-naturalist at Tuolumne Meadows, I discovered several specimens of a dragonfly, *Anax junius* (Drury), frozen into the ice at an altitude of 12,200 feet. The winter of 1971–72 had been unusually mild, resulting in one of the lightest snowpacks of this century. As a consequence, many of the Sierran glaciers retreated, and surfaces of ice deep within them were exposed. These particular dragonflies were undoubtedly swept onto Mount Lyell by upslope winds to perish on the glacier, where they have remained embedded for uncounted years.

R. W. Garrison of the Dept. of Entomological Sciences at the University of California, Berkeley, who confirmed the identification, also noted that one of the females was teneral and was therefore probably trapped on the glacier during her first week of life, possibly on her maiden flight.

Anax junius is a very widespread species, occurring throughout North and Central America. During previous summers in the high Sierra, I have taken numerous specimens in Dana Meadows at Tioga Pass, where it undoubtedly breeds in subalpine lakes there.—R. P. PAPP, *Department of Entomological Sciences, University of California, Berkeley 94720.*